memorandum

Environment and Resources
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To Ashley Allen, EPA

From Emily Giovanni, Molly Cohen, and Elena Besedin, Abt Associates, Inc.

Subject Urban Stream Restoration via Best Management Practices

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The purpose of this literature review is to find papers investigating whether urban-related best management practices (BMPs) can contribute to the recovery of degraded streams. We identified papers that investigated the impact of urban BMPs on in-stream metrics, such as water quality, biotic community and stream morphology. For the most part, studies were temporal, comparing metrics of impaired streams before implementation of BMPs and afterwards. Some studies were longitudinal, comparing streams in areas with and without BMPs. Studies of active stream restoration efforts (i.e. bank stabilization, riparian reforestation etc.), agricultural BMPs, and modeled restoration were excluded from the results.

We identified and reviewed 10 relevant full text studies, which are summarized in Table 1. Findings of BMP effectiveness varied across studies. Some found that BMPs – such as stormwater and drainage retrofits, constructed wetlands and detention ponds – were effective in improving water quality, aquatic habitat conditions, and biotic life (Galli 1998; Cave and Johnson, 2001; Sibling, et al., 2001; Olding et al, 2004; Paragon Consulting, 2004). Others showed that structural BMPs were effective in reducing pollutant loads and helping to control high flow stormwater events, but that channel widening and erosion continued (Booth et al., 2002; Medalie, 2007). These results suggest that BMPs alone are not completely effective at reversing the impacts of urbanization (Horner et al., 2001), but can deliver significantly improved stream quality under certain circumstances. Booth et al. (2002) recommend that, in addition to structural measures, limits to impervious cover, clustered development and riparian buffers be implemented.

It is difficult to compare the results of these studies, because study design and methods vary greatly. Collectively, however, these studies indicate that properly sited and maintained BMPs can mitigate stormwater impacts and maintain or increase in-stream water quality. Nevertheless, no package of BMPs has fully restored stream conditions or biotic indicators to predevelopment levels.

Table 1: Studies of Urban Stream Recoveries via Urban BMP Implementation						
Study	**Location**	**Stream / Urban Characteristics**	**Degree of Degradation**	**BMPs utilized**	**Results**	**Notes**
Galli, 1998	Montgomery County, MD	Urban stream in metropolitan D.C. area -- unstable banks / polluted	Highly degraded	Comprehensive stormwater retrofits SWM / detention ponds Wetland construction and restoration Parallel pipe storm drain systems Riparian reforestation	Improved biological and aquatic habitat conditions Increase in fish species and macroinvertebrates Enhanced stream bank stability Reductions in embeddeness Dramatic reductions in trash, debris and sediment	
Booth et al, 2002	King County, WA	Urban area (1.7 million people in King County) -- increased runoff, peak flows, decreased stability	Severe degradation -- Discharges increased 10-fold	Detention ponds Structural retrofitting	Limited success with detention ponds (still channel erosion) Structural retrofitting helps, but cannot restore predevelopment regime	Recommendations: Control watershed land cover and limit impervious cover (max 20%) Use clustered development to keep forest cover Utilize riparian buffers Detention ponds must control duration flows (not just peaks)

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Medalie 2007	Burlington, VT	Stream in urban watershed was contributing to eutrophication in Lake Champlain -- channel enlargement, decrease in water quality & aquatic diversity	High TN, TP and suspend solids load	Retrofit golf course irrigation pond Structural retrofitting	BMP helped decrease P concentrations in high flow events (>3 cfs) (no reduction in base flow) Possible reduction in overall loads	Reduction was impressive given BMP was 1.7 km from water quality monitoring site with considerable impairment in between Cannot rely on structural BMPs
Paragon Consulting, 2004	Griffin, GA	Stream in area dominated by commercial properties, parking lots, residential development. Elevated nutrients, TSS, orthophosphate, and fecal coliform	Contamination from pollutants associated with urban runoff	Retrofit drainage structures Filter technology and settling devices for urban runoff including: Stormfilter, Baysaver & Crystal Stream	Improved water quality at least slightly for oil & grease, TPH, TP, BOD, COD, Ca, Cu, Mg, Zn, Orthophosphates, Ammonia Nitrogen, Nitrate Nitrogen & Nitrite Nitrogen Slight increase in: TSS, TDS, Pb, Fe, Kjeldahl N	Study used 6 sample sites (two of which were in-stream.) Only results from those two sites were included.

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Olding et al, 2004	Richmond Hill, ON	Urban area, undergoing further urbanization -- 4 to 9% increase in urbanization of study areas	Urban streams were mildly degraded. Due to increasing urbanization, streams are expected to degrade further	Individual detention ponds Goal 70-80% TSS removal Flow control for 2- to 100-year storm Mitigate stream temperature increases	Effective in reducing construction sediment loading Mitigated peak flow and baseflow changes (no increase despite urbanization and increased imperviousness) No increase in water temperature	Study was not pre- versus post-urbanization, but instead presented impact of BMPs on urbanizing watershed, showing that BMPs help mitigate effects of continuing urbanization.
Jones et al, 1996	Prince William County, VA	Suburban and urban areas with BMPs compared to controls	Bank erosion, fish community degradation	Wet ponds Dry ponds Retrofitted culverts Riparian park land	Dry ponds did poor job of mitigation impacts of storm flow Retrofit culvert had little impact on biotic quality (design and maintenance problems) Wet ponds were more successful (better biotic community)	Properly sited BMPs can mitigate stormwater impacts. No BMPs able to restore full complement of biota found in reference watershed.

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Cave & Johnson, 2001	Wayne County, Michigan	Largely urbanized area, population of 1.7 million	Dissolved oxygen deficits, extreme flow, excess nutrients, pathogens from CSOs	CSO upgrades Erosion controls at construction sites Catch basin clearing	Continuing improvement in dissolved oxygen levels In 1994, river met DO standards 30% of time or less, by 2000 met standards 94% of time Increase in numbers and variety of wildlife: fish, birds, macroinvertebrates	Six year study focusing on the lifecycle of variety of BMPs.
Sibling et al, 2001	Sligo Creek & Prince George's County, MD (2 sites)	Intensely developed area -- suburban, urban and industrial	Very poor to fair biological conditions, poor water quality (toxics, debris)	One site had multiple BMP assemblages (SWM, wet retention pond, riparian vegetation, wetlands) Other site had only stormwater retention ponds	BMP assemblages improved benthic metrics Fish surveys showed increased populations (3 species in 1990, 16 in 1996, some of which are pollution sensitive) Single BMPs in isolation may do little to protect or enhance instream biological conditions	Study presents findings from 2 case studies. One was a BMP-assemblage studied without much data on reference conditions. The second evaluated SW retention ponds in isolation against calibrated reference conditions

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Horner et al, 2001	Austin, TX; Montgomery County, MD; Puget Sound, WA; and Vail, CO	Study sites range from no urbanization (reference state) to highly urban with greater than 60% total impervious area.	Biological measures declined as total impervious area increased; hydrological alteration; loss of habitat	BMPs varied by site, but included: Extended detention basins, swales Dry detention ponds, below ground tanks and vaults, infiltration facilities	Structural BMPs mitigate, but do not eliminate, negative impacts on biota BMPs can maintain "fair stream" condition and also help prevent degradation to "bad" condition BMPs do not seem able to maintains "good" conditions However, overall BMP coverage was spotty	Relatively small area served by BMPs, and BMPs can mitigate only a small share of impacts, primarily because of design inadequacies. Nevertheless, structural BMPs can "help sustain aquatic biological communities, especially at moderately high urbanization levels where space limits non-structural options."
Lawrence, 2001	Canberra, Australia	Large inland urbanized area	Impairment typical of urban streams: toxics, debris, nutrients, change in hydrologic regime	Structural BMPs including detention ponds, swales, sediment traps.	Structural BMPs improved levels of total phosphorus, turbidity, and overall biologic diversity. 70% increase in residential property values Benefit-to-cost ratio as high as 4	"BMPs can really deliver"

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